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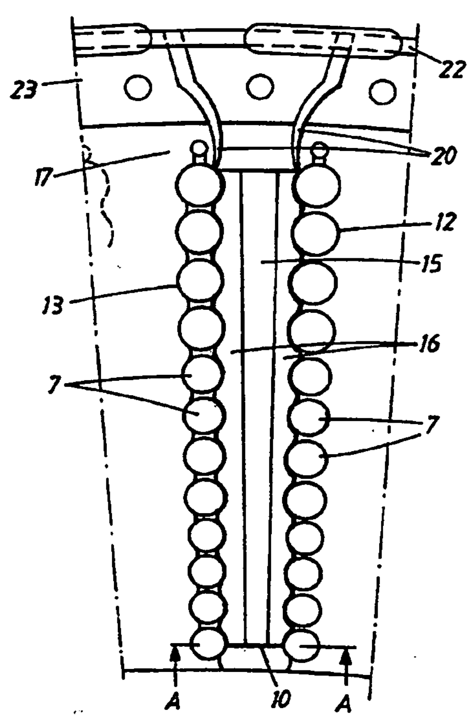
(57) Abstract

The invetion relates to a method for earthing the winding of a rotating electric machine comprising a stator with a stator core (17) and winding (7) arranged in slots in the stator, which is characterized in that earthing takes place between the exit points (25) of the winding from the slots in the stator and the first intersection point (26) between two coil ends of the winding. The invention also relates to an arrangement for performing the method and to a rotating electric machine comprising the arrangement.



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METHOD AND ARRANGEMENT FOR EARTHING A ROTATING ELECTRIC MACHINE, AND A ROTATING ELECTRIC MACHINE

The present invention relates to a method for earthing the winding of a rotating electric machine of the type described in the preamble to claim 1. The invention also relates to an arrangement for earthing as described in the preamble to claim 11 and to a rotating electric machine comprising such an arrangement, of the type described in the preamble to claim 36.

The rotating electric machines referred to in this context comprise synchronous machines, used primarily as generators for connection to distribution and transmission networks, jointly known as power networks. Synchronous machines are also used as motors as well as for phase compensation and voltage control, in that case as mechanically open circuited machines. This technical field also includes normal asynchronous machines, dual-fed machines, alternating current machines, asynchronous static current converter cascades, externalpole machines and synchronous flux machines. These machines are intended for use at high voltages, by which is meant here electric voltages in excess of 10 kV. A typical operating range for such a rotating machine may be 36 to 800 kV, preferably 72.5 - 800 kV.

Rotating electric machines have conventionally been designed for voltages in the range 6-30 kV, and 30 kV has normally been considered to be an upper limit. In the case of a generator, this usually means that the generator must be connected to the power network via a transformer which steps up the voltage to the level of the network, which is in the range of approximately 130-400 kV.

Various attempts have been made over the years to develop especially synchronous machines, preferably generators, for higher voltages. Examples of this are described, for instance, in "Electrical World", October 15 1932, pages 524-525, in the article entitled "Water-and-Oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pages 6-8 and the patent publications US 4,429,244 and SU 955,369. However, none of these attempts has been successful, nor have they led to any commercially available product.

Surprisingly, however, it has proved possible to use high-voltage insulated electric conductors with solid insulation of a type similar to cables for transmitting electric power (e.g. XLPE cables), for the stator winding in a rotating electric machine. This allows the voltage of the machine to be increased to such levels that it can be connected directly to the power network without intermediate transformers. The extremely important advantage is thus gained, int r alia, that the conventional transformer can be eliminated.

Conventional high-voltage generators are usually wound using rod-shaped copper segments which are insulated with epoxy and glassfiber fabric, for instance. Such a stator differs essentially from the sort of stator winding to which the invention relates. The basis of the present invention is that the stator winding is entirely built up of said high-voltage electric conductors with solid insulation. Conventional high-voltage cables are provided with an outer semiconducting layer and an earthed copper sheath which is in continuous electrical contact with the outer semiconducting layer. However, this copper sheath is eliminated in the insulated electric conductors which, as described above, are used in the stator winding in a generator. This creates a need to earth the outer semiconducting layer of the conductor in some other way.

When earthing the outer semiconducting layer, a maximum permissible distance between earthing points must be calculated. This is indicated, for instance, by the resistance per length unit of the semiconducting layer, the capacitance per length unit of the insulated conductor and the phase voltage. The insulated electric conductor preferably consists of an inner, cylindrical, current-carrying conductor with an inner semiconducting layer, a dielectric medium and an outer concentric semiconducting layer. The insulated conductor can therefore be considered as a capacitor where surface charges are always present on the electrodes, the latter consisting of the inner semiconductor and the outer semiconductor. These surfaces charges must be supplied to the electrodes through conduction, i.e. a current must flow from earth to the outer semiconductor, or from the phase conductor to the inner semiconductor. If the surface charges cannot be supplied to the semiconductor sheaths because these are insulated, they will become electrically "floating" and reach impermissible potentials. This is solved by earthing the outer semiconductor at regular intervals. However, the semiconducting layers have relatively high-resistance so that the current transporting the surface charges gives rise to a resistive voltage drop from the earth points to the mid-point between two earth points. This resistive voltage drop must be limited, preferably to below 150 V, since there is otherwise a risk of corona between the insulated conductor and an earthed component, e.g. the stator, in the vicinity. However, this distance is often so long that other factors determine how the earthing should be achieved.

One such factor is that when the insulated conductor is placed in the stator slots in an electric machine, a voltage is induced which produces a circulating current that passes through the earth loops formed at earthing, and along the outer lay r of th insulated conductor. If the outer semiconducting layer is continuously earthed in the slot, a current loop is produced axially through the outer semiconducting layer, radially through the stator laminations, out to the stator

frame and axially back through the stator frame. The current may even be closed around a stator pole. However, the exact distribution of the current outside the insulated conductor is without significance for the current through the outer layer of the insulated conductor, since the resistance through stator laminations and frame is much lower than through the outer layer of the insulated conductor.

If the insulated conductor is placed, insulated, against the slot and is not earthed at its exit from the slot, the circulating current may form a closed circuit via another insulated conductor where the insulated conductors intersect each other in the vicinity of the coil end. This is undesirable since strong heating results locally where the current passes from conductor to conductor. This phenomenon occurs when the current is concentrated to a small area and may cause the temperature to increase to impermissible values.

One solution to the earthing problem is of course to make sure that the insulated conductor is pressed firmly against the earthed stator slot with sufficient force to obtain adequate electrical contact along the entire slot. Provided the insulated conductor abuts the laminations with the same contact resistance everywhere, the current path will primarily form a closed circuit near where the insulated conductor exits and the current will be substantially constant along the insulated conductor. However, there is still a certain risk that a part of the current will form a closed circuit in undesired manner from conductor to conductor, e.g. if the laminations corrode in the stator slots so that contact resistance becomes extremely high.

The object of the present invention is to solve the above-mentioned problems with earthing of the winding in a rotating electric machine for high voltages.

This object is achieved with a method in accordance with the preamble to claim 1 which, in accordance with the present invention, is given the features defined in the characterizing part of the claim.

It is thus stated in claim 1 that earthing takes place between the exit points of the winding from the slots in the stator and the first intersection point between two coil ends of the winding.

The object is also achieved in an arrangement in accordance with the preamble to claim 11 which has been provided with the features defined in the characterizing part of the claim.

Thus, according to claim 11 the winding is made of an insulated electric conductor comprising at least one current-carrying conductor, and also comprising a first layer with semiconducting properties arranged surrounding the current-carrying conductor, a solid insulation layer arranged surrounding said first layer, and a second lay r with semiconducting properti s arranged surrounding the insulation layer, and in that the arrangement comprises earthing devices for applica-

tion against said insulated electric conductor, between the exit points of the winding from the slots in the stator and the first intersection point between two insulated conductors of the winding after leaving the stator.

The solution to the problem is thus that earthing takes place immediately the insulated conductor leaves the slot, before it gets to intersect another insulated conductor in the coil end region. The winding is thus constructed so that its coil ends intersect each other. According to a particularly preferred feature, therefore, earthing takes place immediately where the winding leaves the slots in the stator core.

Earthing takes place through an external device in the form of an earthing device. Naturally this does not prevent earthing also taking place in the stator slot insofar as possible. However, if the insulated conductor is insulated from the stator laminations in the slot, which may be the case under certain circumstances, then only external earthing is possible and is absolutely necessary for the function of the insulated conductor, as well as preventing the current from forming a closed circuit in the vicinity of the coil end.

Additional features and advantages are revealed in the dependent claims.

According to an advantageous feature the method is characterized in that earthing takes place simultaneously and by means of one and the same earthing device, of substantially all the winding turns which, upon leaving the slots in the stator, form a winding row. According to another feature earthing takes place simultaneously and by means of one and the same earthing device, of substantially all the winding turns which are included in two adjacent winding rows.

According to an additional feature of the method the earthing device is inserted between two adjacent winding rows and is then turned, preferably approximately 90°, so that it is brought into contact with substantially all the winding turns in at least one of the adjacent winding rows. This contact is preferably resilient so that a certain pre-stressing occurs to ensure firm abutment against the winding turns, i.e. the outer semiconducting layer of the insulated conductors.

According to the arrangement in accordance with the invention the high-voltage electric conductor may be designed in many advantageous ways. The insulated conductor or high-voltage cable used in the present invention is flexible and is of the type described in more detail in WO 97/45919 and WO 97/45847. The insulated conductor or cable is further described in WO 97/45918, WO 97/45930 and WO 97/45931.

Thus, as mentioned previously, the windings are pr f rably of a type corresponding to cables having solid, extruded insulation, like those currently us d for power distribution, such as XLPE-cabl s or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strand parts, an

inner semiconducting layer surrounding the conductor, a solid insulating layer surrounding this and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this context since the technology for the device according to the invention is based primarily on winding systems in which the winding is formed from conductors which are bent during assembly. The flexibility of a XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable 30 mm in diameter, and a radius of curvature of approximately 65 cm for a cable 80 mm in diameter. In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature in the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

The winding should be constructed to retain its properties even when it is bent and when it is subjected to thermal or mechanical stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In a XLPE-cable, for instance, the insulating layer consists of cross-linked, low-density polyethylene, and the semiconducting layers consist of polyethylene with soot and metal particles mixed in. Changes in volume as a result of temperature fluctuations are completely absorbed as changes in radius in the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, the radial expansion can take place without the adhesion between the layers being lost.

The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having resistivity within the range of 10^{-1}-10^{6} ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of the invention.

The insulating layer may consist, for example, of a solid thermoplastic material such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentene ("TPX"), cross-linked materials such as cross-linked polyethylene (XLPE or PEX), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

The inner and outer semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by wh ther soot or m tal powder is mixed in or not - at least in the proportions required to achieve the conductivity

necessary according to the invention. The insulating lay r and the semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymer/nitrile rubber, butylgraft polyethylene, ethylene-acrylate-copolymers and ethylene-ethyl-acrylate copolymers may also constitute suitable polymers for the semiconducting layers.

Even when different types of material are used as base in the various layers, it is desirable for their coefficients of thermal expansion to be of substantially the same magnitude. This is the case with the combination of the materials listed above.

The materials listed above have relatively good elasticity, with an E-modulus of E<500 MPa, preferably <200 MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks or other damage appear and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion between the layers is at least of the same magnitude as in the weakest of the materials.

The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently high to contain the electrical field within the cable, but at the same time sufficiently low not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.

Thus, each of the two semiconducting layers essentially constitutes one equipotential surface, and the winding comprising these layers will substantially enclose the electrical field within it. The first layer is also at substantially the same potential as the current-carrying conductor. The second layer is preferably arranged to constitute a substantially equipotential surface surrounding the current-carrying conductor(s). It is also connected to a predetermined potential, preferably earth potential.

There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

The insulated conductor or cable also preferably has a diameter within the interval 20-250 mm and a conducting area within the interval 80-3000 mm^2. According to further features the current-carrying conductor may comprise a number of strand parts, only a few of which are not insulated from each other. Finally, each of the three layers may be firmly joined to the adjacent layer along essentially its entire contact surfac .

The arrangement according to the invention is also particularly characterized in that the earthing device comprises at least one resilient part and at l ast one l ment made of an electrically conducting mat rial. The arrangement may

also comprise an earthing member connecting the earthing device to earth potential, preferably by earthing in the stator frame. This member may be an earth wire and it may be constituted of a metal braid or a solid copper conductor running circularly around the whole stator and lying outside/above the coil ends. Other embodiments are also feasible.

The resilient part of the earthing device and the conducting element are preferably arranged on a support made of a relatively stiff electrically conducting material. This support may consist of a glassfiber rod, for instance, or a plate of glassfiber laminate.

The earthing device preferably has longitudinally extended form so that, upon application, it is in contact with the insulated conductor of substantially all the winding turns which, when leaving the slots in the stator, form a winding row. Normally, the number of winding turns is 12, which then together form a winding row.

According to a first embodiment the resilient part of the earthing device is arranged along at least one of the long sides of the earthing device which side, after application, faces towards the insulated conductors in a winding row so that the earthing device is in resilient contact with the insulated conductors. The resilient part of the earthing device may advantageously be arranged along both longitudinal sides. According to this embodiment the element made of electrically conducting material extends along the earthing device so that, after application of the earthing device against the insulated conductors, it is located between the resilient part and the insulated conductors and is in contact with substantially all insulated conductors in a winding row.

According to a second embodiment the resilient part is arranged in the dividing plane of the earthing device, the element made of electrically conducting material then being attached to the support of the earthing device, the latter thus being divided into two halves by the resilient part.

In both these embodiments the resilient part may be designed in various ways. Examples are a die-cast rubber section, a leaf spring, a helical spring, a corrugated laminate or a corrugated (intermediate) layer, etc.

According to a third embodiment the earthing device may have several resilient parts - one situated centrally, e.g. in the form of a corrugated (intermediate) layer, which is surrounded on each side by two support halves, and two additional resilient parts on the outsides of the support halves, e.g. in the form of rubber profiles. This arrang ment gives the advantage of extra flexible r silience.

The electrically conducting element may also be designed in several ways, such as in th form of a metal tape e.g. of aluminium, or a m tal braid, e.g.

of copper. A metal braid has the particular advantage of offering a certain amount of stretch, which may be needed when the resilient member is partially deformed upon application between the winding rows. It is also important for the electrically conducting element to have a large contact surface with the conductor of the winding. The electrically conducting element is preferably attached to the resilient part, or alternatively to the support, by means of gluing, for instance.

In fourth and fifth embodiments the resilient part and the electrically conducting element may be designed as a single, combined member having both resilient and electrically conducting properties. Such a combined member may consist, for instance, of a helical spring of electrically conducting material, of a rubber profile strip that has been made semiconducting by filling silicone rubber with soot particles or silver flakes, for instance, or it may alternatively comprise an earthing element with higher conductivity than the semiconducting rubber, such as a copper wire. However, the importance of a relatively large contact area is here emphasized.

As additionally an advantageous feature it is stated that the earthing device is in contact with the stator surface. It is advantageously also attached to the stator surface, e.g. glued or screwed on. The earthing device may advantageously be earthed via the stator surface, without any separate earthing member. However, in many case this is not possible since the ends of the stator may be provided with a protective stator plate. When the term "stator core" or "stator surface" is mentioned in this description, it refers where applicable to a stator core or stator surface including such a plate if present. However, it is presumed that when earthing takes place via the stator surface it does not have any stator plate.

A particularly important feature is stated to be that, in all its embodiments, the earthing device may be symmetrical in relation to its longitudinal axis, which thus has the advantage that the earthing device connects all insulated electric conductors in the winding rows of both sides of the device to earth.

Finally, the arrangement has the advantage of also comprising members to electrically insulate intersecting coil ends of the winding from each other in the coil end region. This constitutes an additional safety precaution to make absolutely sure that no current forms a closed circuit between two insulated conductors in the coil end region.

The invention also comprises a rotating electric machine, as described previously, which is characterized in that it comprises an arrangement as defined above.

According to a particularly advantageous embodiment the machine is provided with earthing devices appli d b tw en at least alternate winding rows, or

alternatively between every winding row. The method in accordance with the invention reveals corresponding features.

To increase understanding of the invention, it will now be described in detail with reference to the accompanying drawings illustrating embodiments of the invention by way of example, in which drawings:

Figure 1 shows schematically a first embodiment of an arrangement according to the invention, seen from above, comprising an earthing device inserted between two winding rows, as well as an earthing member,

Figure 2 shows the earthing device in Figure 1, seen from the side and partially in section, inserted between two winding rows,

Figure 3 illustrates schematically and only partially an earthing device according to a second embodiment of the invention, seen from above and inserted between two winding rows,

Figure 4 shows schematically a third embodiment of an earthing device, seen from above,

Figure 5 shows schematically a fourth embodiment of an earthing device, seen from above,

Figure 6 shows schematically a fifth embodiment of an earthing device, seen from the side,

Figure 7 shows a first variant of the first embodiment of the earthing device, seen from the side and in section,

Figure 8 shows a second variant of the first embodiment of the earthing device, seen from the side and in section,

Figure 9 shows a cross section through an insulated conductor suitable for the winding in the rotating electric machine according to the present invention.

The insulated conductor or cable, illustrated in Figure 9, comprises at least one current-carrying conductor 1, a first layer 2 with semiconducting properties surrounding this, a solid insulation layer 3 surrounding said first layer and a second layer 4 with semiconducting properties surrounding the insulation layer. The current-carrying conductor 1 may also comprise a number of strand parts 6. The three layers are achieved in such a way that they adhere to each other even when the cable is bent. The cable shown is flexible and this property is retained throughout its service life.

Figure 1 illustrates schematically a first embodiment of an earthing device 10 applied on the stator, or in its immediate proximity, in a rotating electric machine, between two winding rows 12, 13. The stator comprises stator slots for the winding and, where the turns of th winding leave the stator slots at the end of the stator, they form rows, one for each stator slot. Tw lve winding turns are usually

included in a winding row 12, 13, the winding in accordance with the invention consisting of insulated electric conductors 7. The earthing device 10 extends longitudinally so that it can earth all conductors simultaneously. The earthing device here comprises a support 15 on each side of which, i.e. the long sides of the earthing device which in the figure are in contact with the insulated conductors, is provided resilient parts 16. These resilient parts are in turn provided with elements 18 made of electrically conducting material, which abut against the insulated conductors. The earthing device is preferably symmetrical along its longitudinal axis. The arrangement also includes an earthing member 20 for connecting the earthing device to a suitable earth point, e.g. an earth wire 22 which is earthed in the stator frame 23.

Figure 2 illustrates the earthing device seen from the side. Here the support 15 is seen provided with resilient parts 16, the outside of which facing the insulated electric conductors 7, are provided with electrically conducting elements 18. The earthing device is here in contact with the end surface of the stator core 17. However, the earthing device could also be placed a short distance from the stator core. It must, however, be located between the exit points 25 of the insulated conductors from the stator core and the first intersection point 26 between two insulated conductors in the vicinity of the coil ends.

The parts of the earthing device are revealed more clearly in Figure 3 which is an enlarged view of a second embodiment of the earthing device. The elements, in this figure and in following figures showing other embodiments and variants, which correspond to previously mentioned elements have been given the same reference numerals. A dividing plane 28 for a centrally placed resilient part 26 is shown. In the figure it is drawn as a rubber element but it may also consist of a spring, e.g. a leaf spring, a helical spring or a corrugated laminate. The support 27 is here divided into two parts, one on each side of the resilient part 26. An electrically conducting element 18 is arranged on the outside of the support. With reference to this embodiment another embodiment may be mentioned comprising a combined support and resilient part made of the same material, e.g. rubber.

Figure 4 illustrates a third embodiment comprising a centrally located resilient part in the form of a corrugated (intermediate) layer 33. The support 27 is here divided into two parts, surrounding the corrugated (intermediate) layer. Outside the support are two additional resilient parts 34, to which the electrically conducting elements 18 abutting the conductors 7 are attached.

Figure 5 shows a fourth embodiment in which the resilient part and the electrically conducting l m nt are combined to a common m mber, on both sides of a support 30. Th combined member consists pref rably of a metallic, helically shaped spring 31 and, according to the figure, such a spring has b en

applied on both sides of the support 30. Alternatively, as mentioned, the support and the resilient part may be made in one piece, e.g. in the form of a rubber support.

Figure 6 shows schematically a fifth embodiment of an earthing device in which all three functions are combined in a single member, namely a rubber strip profile 36 which has been made semiconducting by particles 37 of conducting material having been mixed into it. The size of the particles has been greatly exaggerated in the figure for the sake of clarity. They are normally so small as to be hardly visible in the figure.

Figure 7 shows a first variant of an embodiment of the earthing device in accordance with the invention. The earthing device in Figure 7, shown in section, thus comprises a support 15, provided with resilient parts 16 on its two longitudinally running sides. Elements 18 of an electrically conducting material are arranged on the outside of these resilient parts, for abutment against the insulated electric conductors. These elements are then connected to the earth wire which in turn is connected to earth, e.g. the stator frame. The embodiment illustrated in Figure 8 differs from that shown in Figure 7 in that the electrically conducting element is here applied on the lower side of the earthing device, i.e. the side that will face the end surface of the stator core. The conducting element 40 is so designed that it extends past the long sides of the earthing device in transverse direction, a distance that preferably corresponds at least to the height of the earthing member, i.e. the side in contact with the insulated conductors. When the earthing device has been applied between the conductors, the parts 42 of the conducting element that protrude at the sides will be folded up, since they are made of a flexible material, and will enter into contact with the sides of the earthing device when this has been installed between the winding rows.

The arrangement functions generally as follows: The earthing device is inserted between two winding rows while "standing" on its long side, i.e. it is turned approximately 90° in relation to the position it will have when installed. When the earthing member has been fully inserted between the windings it is turned 90° back again. When this is done the sides of the earthing device will be pressed against the conductors of the winding, against the action of the resilient part which will thus be somewhat deformed. When the earthing device has been turned to its correct position, therefore, pre-stressing will prevail in the resilient part and this helps so keep the device in place and improves the electrical contact between the electric elem nt of the device and the conductors of the winding. Earthing is finally effected by the earthing d vice being connected to th arth wire. Alternatively, the earthing device is earthed directly through contact with the stator core.

Naturally a number of modifications are possible, particularly as r gards the design of the electric element and its attachment to the earthing device. Furthermore, in most of the above cases the earthing device has been described as a profile, i.e. with its side to follow the profile of the winding rows. However, a more or less straight side may also be possible. The embodiments described above by way of example should not therefore be understood as limiting. A number of modifications are possible within the scope of the appended claims. In particular should be mentioned the possibilities of various combinations of the examples shown with regard to support, resilient parts and electrically conducting elements, that can be considered obvious to one skilled in the art.

CLAIMS

1. A method for earthing the winding of a rotating electric machine comprising a stator with a stator core (17) and winding (7) arranged in slots in the stator, **characterized** in that earthing takes place between the exit points (25) of the winding from the slots in the stator and the first intersection point (26) between two coil ends of the winding.

2. A method as claimed in claim 1, **characterized** in that earthing takes place in the immediate proximity of the winding's exit from the slots in the stator.

3. A method as claimed in claim 1 or claim 2 **characterized** in that earthing takes place simultaneously and by means of one and the same earthing device (10), of substantially all the winding turns which, upon leaving the slots in the stator, form a winding row (12, 13).

4. A method as claimed in claim 3, **characterized** in that earthing takes place simultaneously and by means of one and the same earthing device (10), of substantially all the winding turns which are included in two adjacent winding rows (12, 13).

5. A method as claimed in claim 3 or claim 4, **characterized** in that the earthing device (10) is inserted between two adjacent winding rows (12, 13) and is then turned, preferably approximately 90^{o}, so that it is brought into contact with substantially all the winding turns in at least one of the adjacent winding rows.

6. A method as claimed in claim 5, **characterized** in that earthing devices (10) are applied between at least every second winding row (12, 13).

7. A method as claimed in claim 6, **characterized** in that an earthing device (10) is applied between every winding row (12, 13).

8. A method as claimed in any of the preceding claims, **characterized** in that the earthing device (10) is applied so that it is in contact with the surface of the stator.

9. A method as claimed in any of the preceding claims, **characteriz d** in that earthing d vices (10) are applied at both ends of th stator.

10. A method as claimed in any of the preceding claims, **characteriz d** in that intersecting coil ends of the winding are insulated electrically from each other in the coil end region.

11. An arrangement for earthing the winding of a rotating electric machine comprising a stator with a stator core (17) and winding (7) arranged in slots in the stator, **characterized** in that the winding is made of an insulated electric conductor (7) comprising at least one current-carrying conductor (1), and also comprising a first layer (2) with semiconducting properties arranged surrounding the current-carrying conductor, a solid insulation layer (3) arranged surrounding said first layer, and a second layer (4) with semiconducting properties arranged surrounding the insulation layer, and in that the arrangement comprises earthing devices (10) for application against said insulated electric conductor, between the exit points (25) of the winding from the slots in the stator and the first intersection point (26) between two insulated conductors of the winding after leaving the stator.

12. An arrangement as claimed in claim 11, **characterized** in that the layers (2, 3, 4) are arranged to adhere to each other even when the insulated conductor is bent.

13. An arrangement as claimed in claim 11 or claim 12, **characterized** in that the second layer (4) is arranged so that it constitutes a substantially equipotential surface surrounding the current-carrying conductor(s) (1).

14. An arrangement as claimed in any of claims 11-13, **characterized** in that the second layer (4) is connected to earth potential.

15. An arrangement as claimed in any of claims 11-14, **characterized** in that at least two adjacent layers have substantially equal coefficients of thermal expansion.

16. An arrangement as claimed in any of the preceding claims, **characterized** in that the earthing device (10) comprises at least one resilient part (16; 26; 31; 33,34) and at least one element (18; 31; 40,42) made of an electrically conducting material.

17. An arrangem nt as claimed in claim 16, **characterized** in that it comprises an earthing member connecting the arthing device to earth potential.

18. An arrangem nt as claim d in claim 16 or claim 17, **characterized** in that the resilient part (16; 26; 31; 33,34) of the earthing device and the conducting element (18; 31; 40,42) are arranged on a support (15; 27; 30) made of a relatively stiff electrically conducting material.

19. An arrangement as claimed in any of claims 16-18, **characterized** in that the earthing device (10) has longitudinally extended form so that, upon application, it is in contact with the insulated conductor (7) of substantially all the winding turns which, when leaving the slots in the stator, form a winding row (13, 14).

20. An arrangement as claimed in claim 19, **characterized** in that the resilient part (16; 26; 31; 33,34) of the earthing device is arranged along at least one of the long sides of the earthing device which side, after application, faces towards the insulated conductors (7) in a winding row so that the earthing device is in springing contact with the insulated conductors.

21. An arrangement as claimed in any of claims 19-20, **characterized** in that the element (18; 31; 40,42), made of electrically conducting material, extends along the earthing device (10) so that, after application of the earthing device against the insulated conductors (7), it is located between the resilient part (16; 26; 33,34) and the insulated conductors and is in contact with substantially all insulated conductors in a winding row.

22. An arrangement as claimed in any of claims 19-21, **characterized** in that the resilient part (26; 33) of the earthing device is arranged in the dividing plane (28) of the earthing device.

23. An arrangement as claimed in any of claims 16-22, **characterized** in that the resilient part (16; 26; 34) consists of a die-cast rubber profile, a spring (31) or a corrugated (intermediate) layer (33).

24. An arrangement as claimed in any of claims 16-23, **characterized** in that the electrically conducting element consists of a metal tape or a metal braid.

25. An arrangement as claimed in any of claims 16-21, **characterized** in that the resilient part and the electrically conducting element are designed as a single, combined member (31; 36) having both r silient and electrically conducting properties.

26. An arrangement as claimed in claim 25, charact rized in that the combined member consists of a helical spring (31) of electrically conducting material.

27. An arrangement as claimed in claim 25, **characterized** in that the combined member consists of a rubber profile (36) that has been made semiconducting.

28. An arrangement as claimed in claim 27, **characterized** in that the semiconducting rubber profile also comprises an earthing element with higher conductivity than the semiconducting rubber.

29. An arrangement as claimed in any of claims 16-28, **characterized** in that the earthing member (20) is earthed in the stator frame and in that it comprises an earth wire or an earthing braid.

30. An arrangement as claimed in any of claims 11-29, **characterized** in that the earthing device (10) is in contact with the stator surface.

31. An arrangement as claimed in claim 30, **characterized** in that the earthing device (10) is attached to the stator surface.

32. An arrangement as claimed in any of claims 30-31, **characterized** in that the earthing device (10) is earthed via the stator surface.

33. An arrangement as claimed in any of the preceding claims, **characterized** in that the earthing device (10) is symmetrical in relation to its longitudinal axis.

34. An arrangement as claimed in any of the preceding claims, **characterized** in that several earthing devices are joined together via their ends facing the stator frame.

35. An arrangement as claimed in any of claims 11-34, **characterized** in that it also comprises members to electrically insulate intersecting coil ends of the winding from each other, in the coil end region.

36. A rotating electric machine comprising a stator with a stator core and winding arranged in slots in the stator, **characteriz d** in that it compris s an arrangement as defined in any of claims 11-35.

37. A rotating electric machine as claimed in claim 36, **charact riz d** in that an earthing device is applied between at least every second winding row, a winding row consisting of those winding turns that leave the stator from the same stator slot.

38. A rotating electric machine as claimed in claim 37, **characterized** in that an earthing device is applied between every winding row.

Fig. 1

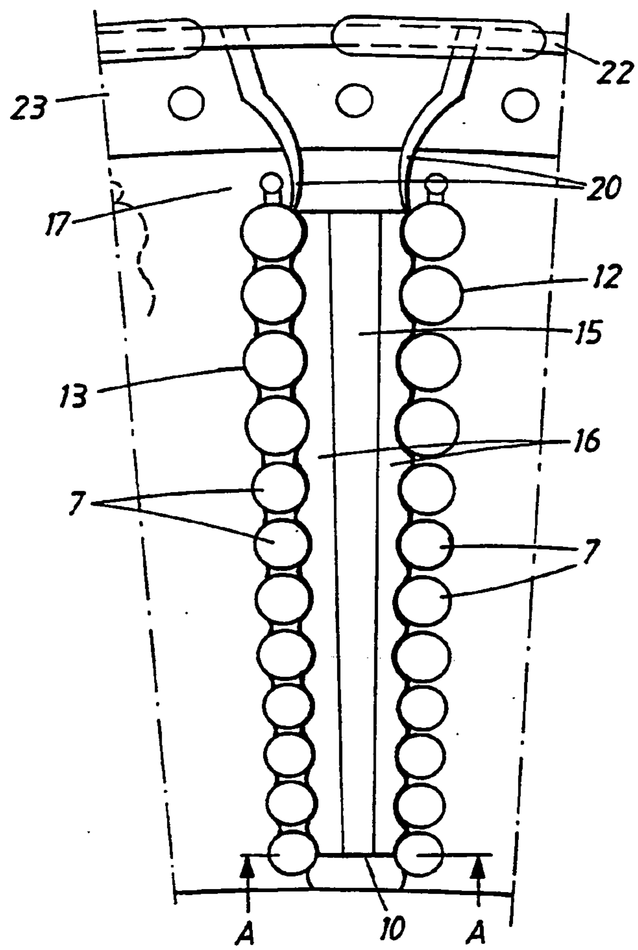

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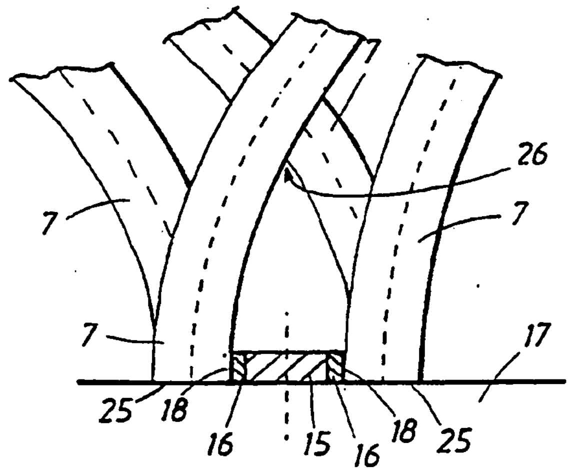
Fig. 2



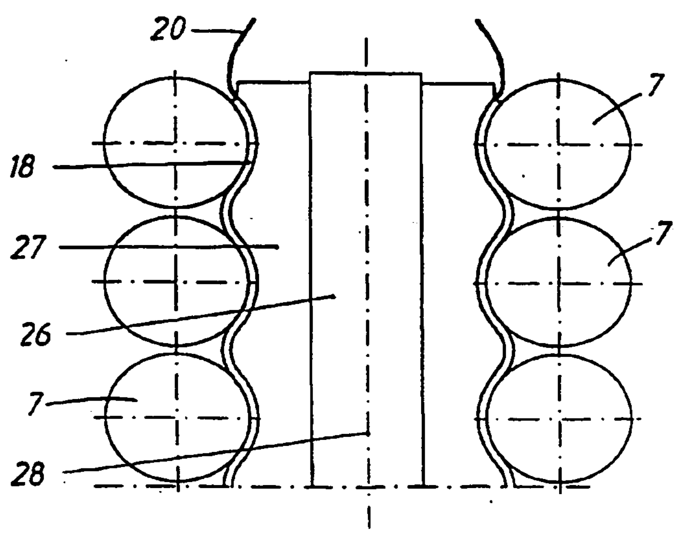


Fig. 3

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Fig. 4

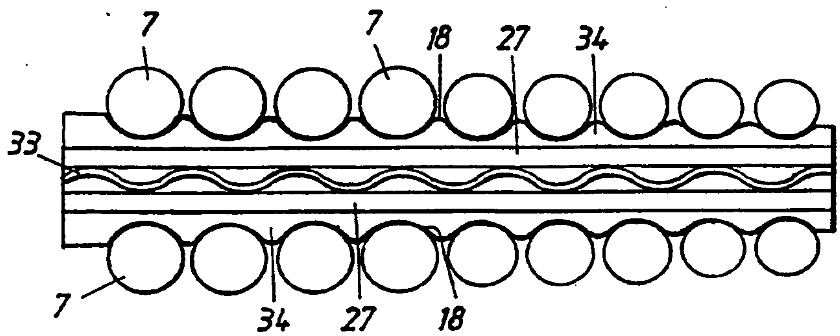

Fig. 5

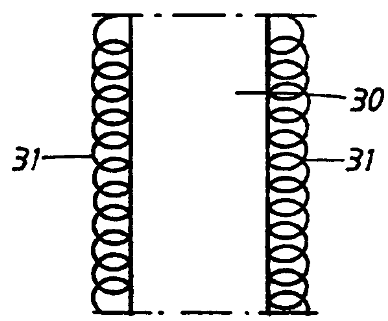

Fig. 6

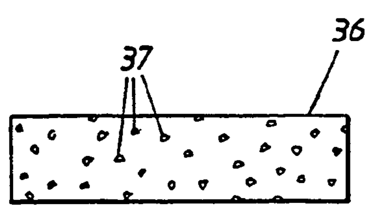

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Fig. 7

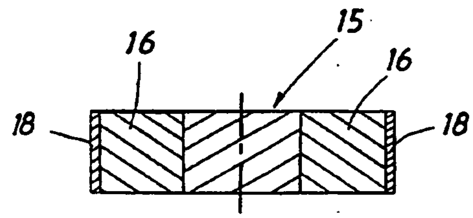


Fig. 8

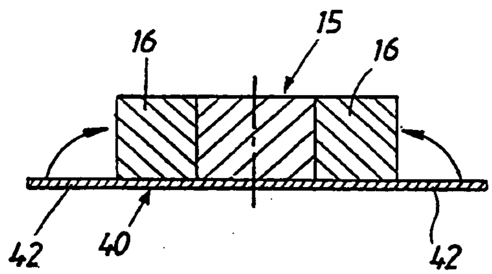
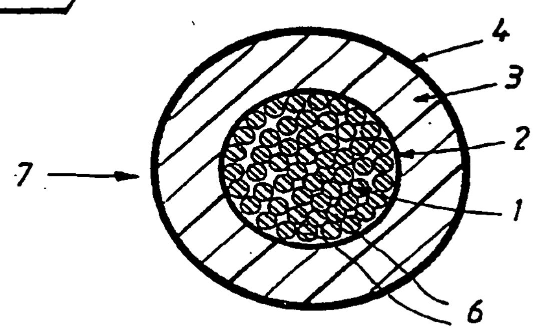


Fig. 9



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01742

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 3/40
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EDOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	 --	12
X	DE 399790 B (ELIN ENERGIEVERSORGUNG GESELLSCHAFT M.B.H.), 25 July 1995 (25.07.95), figure 2, abstract --	1,11,36

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 December 1998	29 -12- 1998
Name and mailing address of the ISA/ Swedish Patent Offic Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Karin Säfsten Telephone No. +46 8 782 25 00

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